SNS COLLEGE OF TECHNOLOGY

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COIMBATORE-641 035, TAMIL NADU

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Course Name: 23ECT203 LINEAR INTEGRATED CIRCUITS

II YEAR/VI SEMESTER

UNIT I –BASICS OF OPERATIONAL AMPLIFIERS

Topic :DC Characteristics

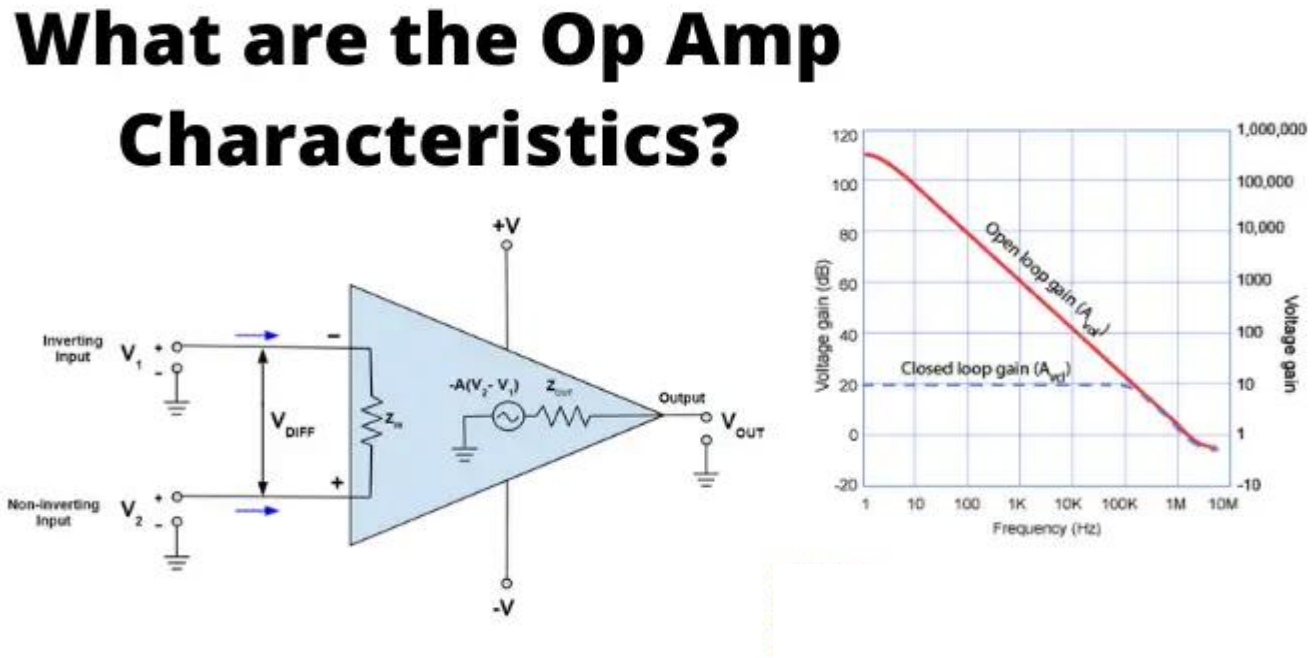
Introduction to DC Characteristics

ⓘ What are DC Characteristics?

- Parameters describing op-amp behavior with **DC signals**
- Behavior in **quiescent state** (no signal)

! Why are they important?

- Real op-amps are **not ideal**
- DC imperfections cause **output errors**
- Critical for **precision applications**
- Essential for **sensor interfaces** and **instrumentation**



Stage 2: Define

Defining requirements for understanding DC parameters

Learning Goals

- Define key parameters: **Vos, Ib, Ios**
- Understand the **physical origin** of each parameter
- Learn to **model their effect** on a circuit
- Calculate the resulting **DC output error**

Input Offset Voltage (Vos)

Voltage needed between inputs to zero output

Input Bias Current (Ib)

Average of currents into the two inputs

Input Offset Current (Ios)

Difference between the two input currents

Stage 3: Ideate

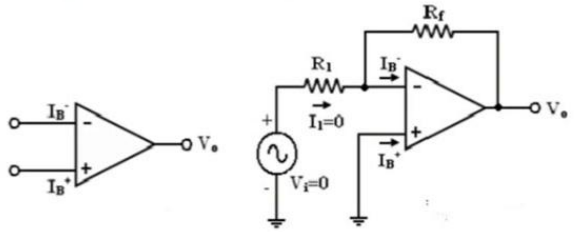
Brainstorming approaches to analyze DC errors

Approaches

- Analyze **manufacturer datasheets** for typical/max values
- Use **superposition** to calculate effect of each error source
- Create **simplified DC equivalent** circuit models
- Simulate circuits using **SPICE** to verify calculations

DC Characteristics of op-amp

- **Input bias current:**



- I_B^+ & I_B^- are the currents flowing in base of transistors

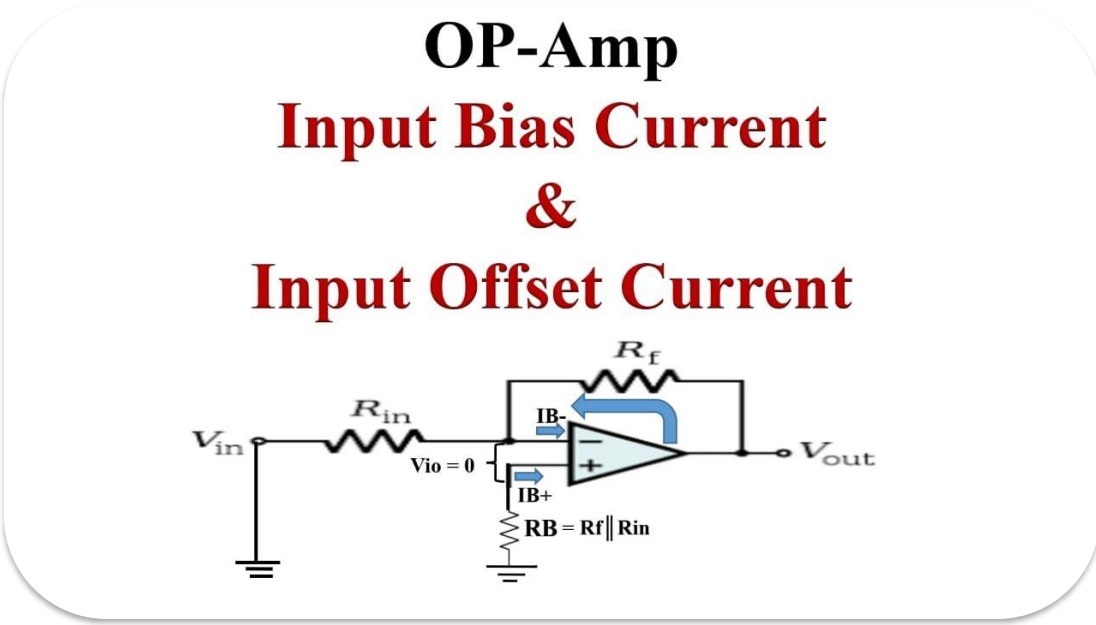
$$\text{Bias Current } I_B = \frac{I_b^+ + I_b^-}{2}$$

Stage 4: Prototype

Creating a DC error model of an op-amp

The Model

1. Start with an **ideal op-amp symbol**
2. Add a **voltage source (Vos)** in series with one input
3. Add **current sources (Ib)** to both inputs
4. Model helps **predict the DC error** at the output

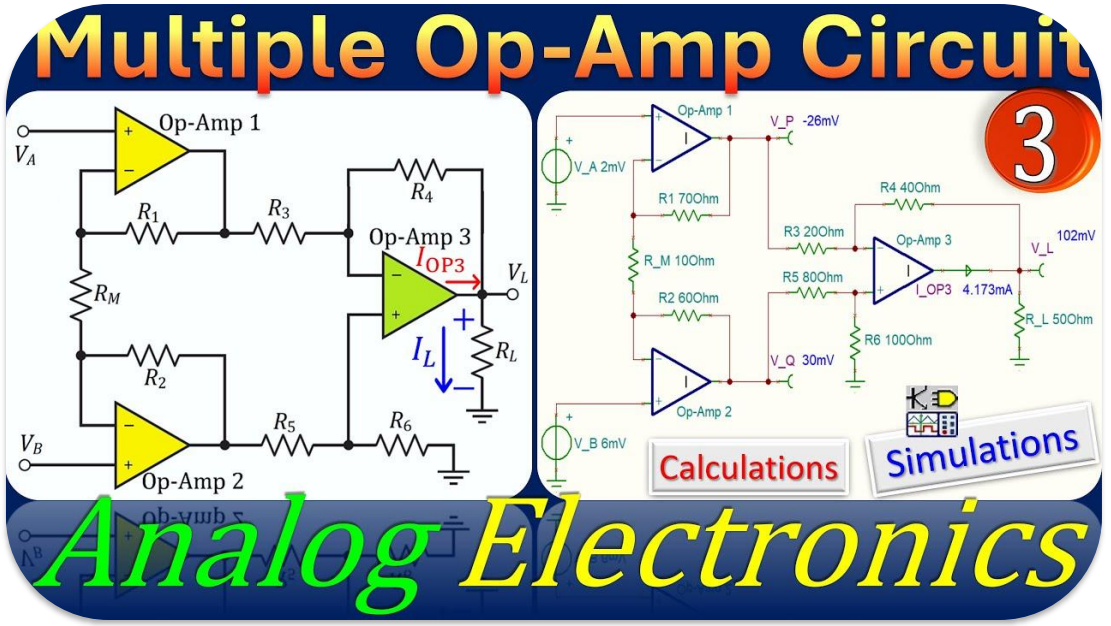


Stage 5: Test

Testing and evaluating DC error calculations

Testing Method

1. Choose a **simple circuit** (e.g., inverting amplifier)
2. Use the **DC error model** to calculate expected output voltage
3. Compare the calculated result with a **SPICE simulation**
4. **Analyze discrepancies** and refine the model



Input Bias & Offset Current (Ib & Ios)

Input Bias Current (Ib)

Definition: Average of currents into the two inputs

Formula: Ib = (Ib+ + Ib-) / 2

Cause: Base bias current of differential input transistors

Typical Values: Nanoamps (nA) range

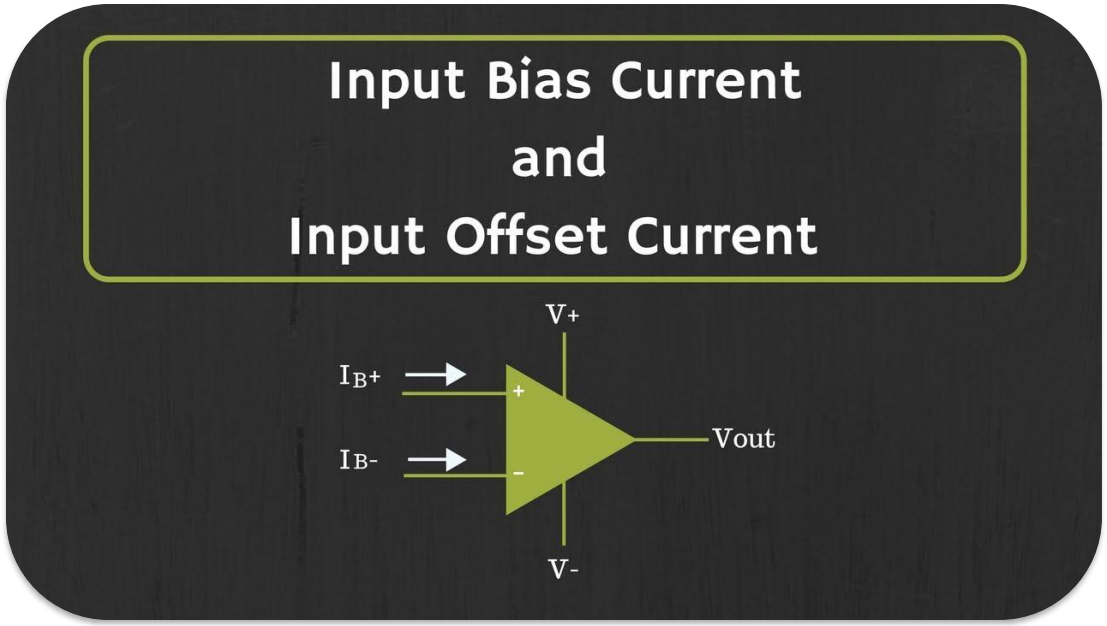
Input Offset Current (Ios)

Definition: Difference between the two input currents

Formula: Ios = |Ib+ - Ib-|

Cause: Mismatch in input transistor betas (β)

Typical Values: 10-20% of Ib



Input Offset Voltage (Vos)

Definition

DC voltage that must be applied between inputs to force output to **zero volts**

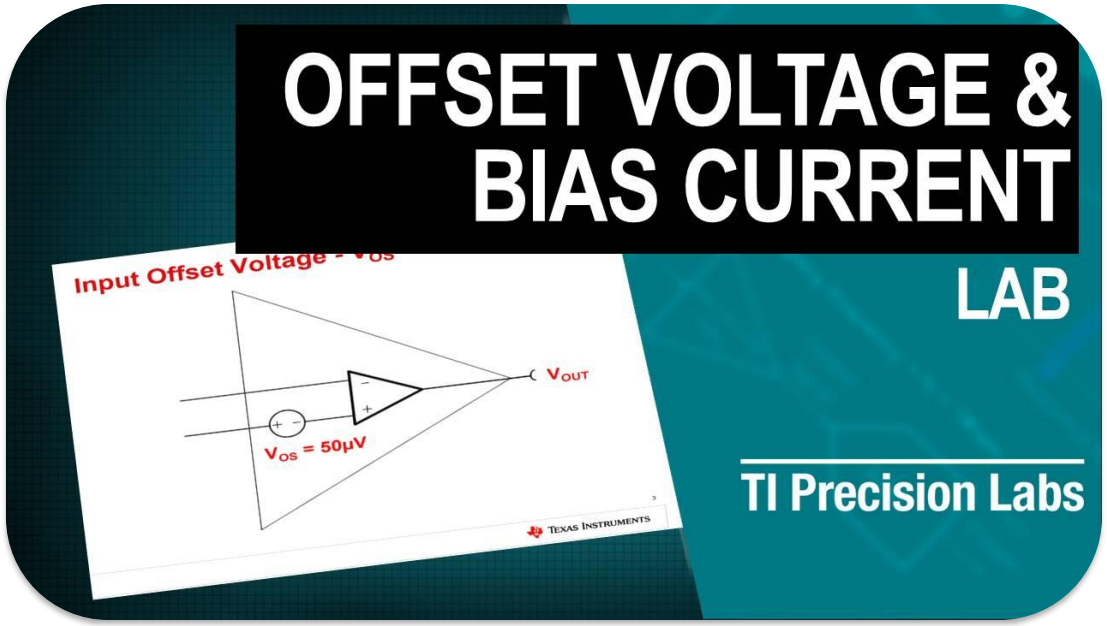
Cause

Mismatches in input stage transistors:

- Base-emitter voltage (Vbe) differences
- Collector resistance (Rc) differences

Effect & Values

- Acts like a **small DC source** in series with input
- Causes **output error** proportional to circuit gain
- Typical values: **1-5 mV** for 741 op-amp



Output DC Errors & Minimization

Total Output Error

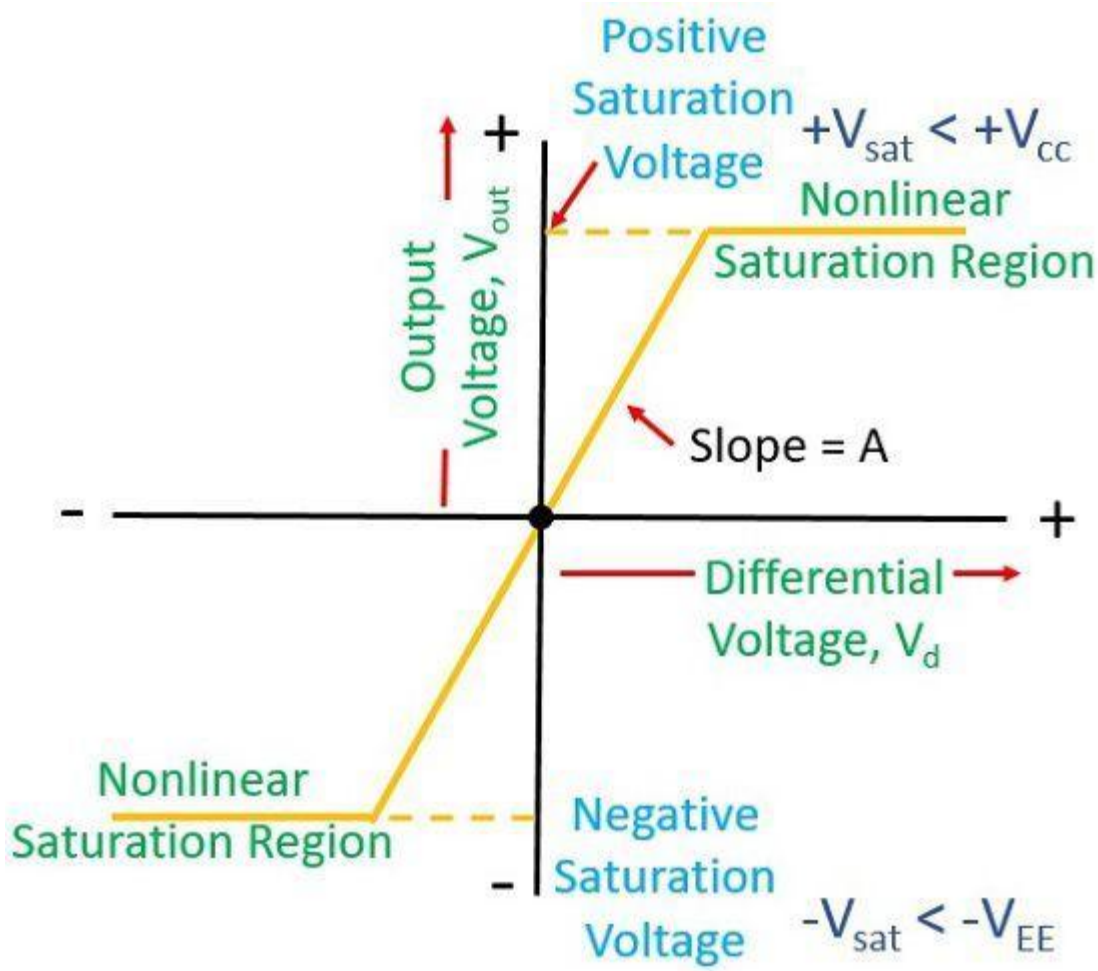
- Sum of errors caused by **Vos**, **Ib**, and **Ios**
- $V\_error\_out = (1 + Rf/R1) \times Vos + Rf \times Ib + Rf \times Ios$

Minimizing Ib Error

- Add **compensating resistor** (Rcomp) to non-inverting terminal
- $Rcomp = R1 \parallel Rf$ (for inverting amp)
- Makes resistance seen by both inputs **equal**

Other Parameters

- **CMRR**: Rejects common-mode DC
- **PSRR**: Rejects supply ripple



Activity: THINK-PAIR-SHARE

THINK (2 min)

An inverting amplifier has a gain of -10 and a **Vos** of 2mV. What is the output DC error due to Vos alone?

PAIR (3 min)

Discuss your calculation and method with a partner

SHARE (5 min)

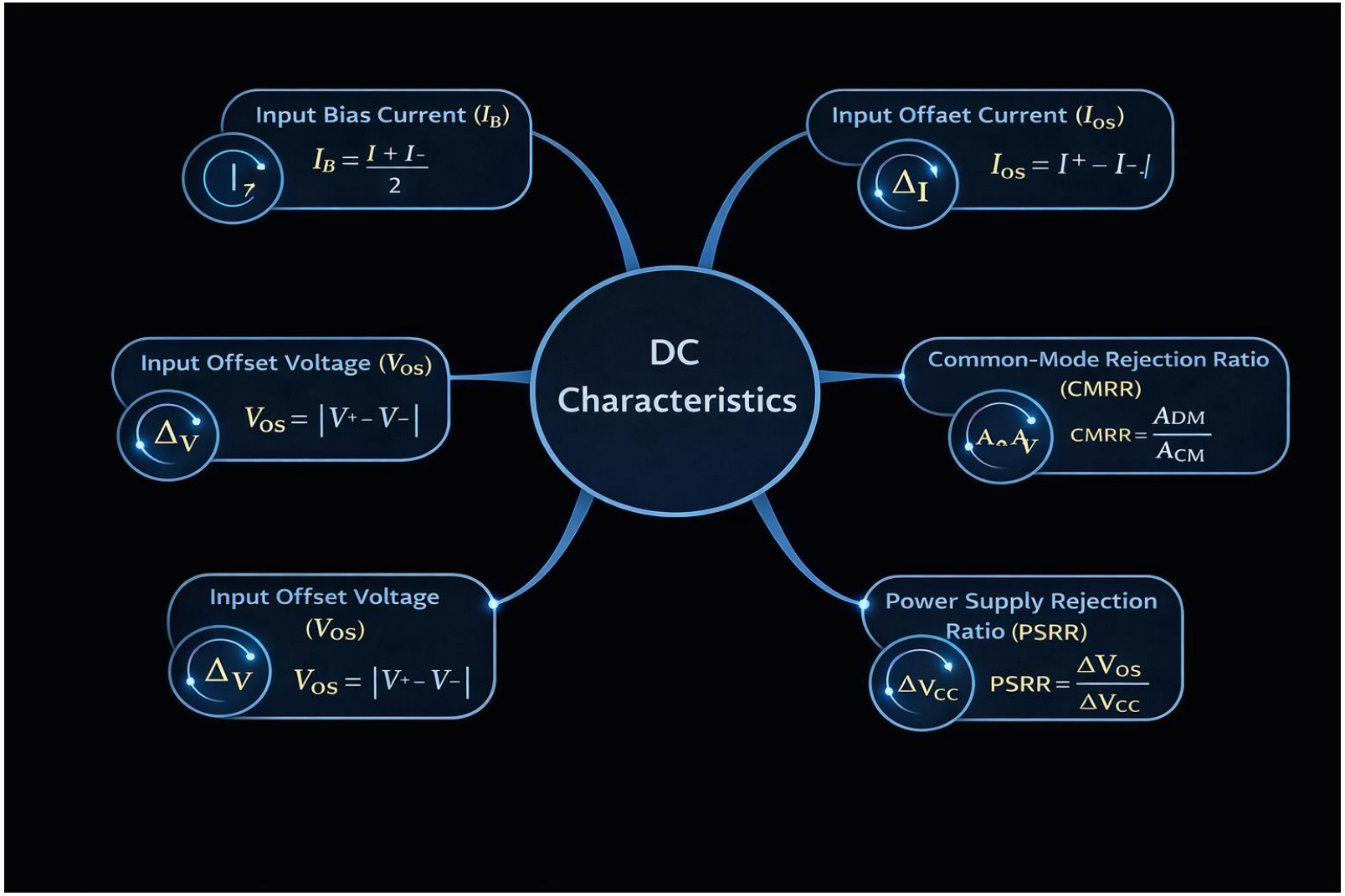
Be ready to share your answer and the formula you used

Individual Thinking

Partner Discussion

Group Sharing

Summary:Mind Map



Assessment

Exam-Oriented Questions

1. Define **Input Offset Current** and state its typical value for a 741 op-amp.

2. Draw the **DC error model** of an op-amp including Vos and Ib.

3. Why is a resistor connected to the **non-inverting terminal** of an op-amp in a practical inverting amplifier?

4. List two causes for **input offset voltage**.

References

Textbooks

D.Roy Choudhry, Shail Jain, **"Linear Integrated Circuits"**, New Age International, 5th edition, 2018. (Unit I, Section 1.4)

Sergio Franco, **"Design with Operational Amplifiers and Analog Integrated Circuits"**, 4th Edition, Tata Mc Graw-Hill, 2014. (Chapter 2)

Online Resource

Texas Instruments, **"Op-amp Basics: Introduction to the Operational Amplifier"**, [Link to TI E2E or technical document]

Textbooks

Online Resources

THANK YOU